CLAIMS:

1. A heat exchange system for a drying apparatus including:

a drying gas to remove moisture from the material being dried, and

a heat source heat exchanger containing a heat source medium to heat the material being dried primarily by conduction and/or convection configured in such a way that the majority of heat transferred to the material being dried does not first pass through the drying gas stream so the drying gas stream primarily carries moisture away from the material being dried but does not carry the majority of heat into the material being dried, and

a heat sink heat exchanger containing a heat sink medium to cool and condense liquid out of a drying gas.

2. A heat exchange system according to claim 1 where at least part of the heat sink heat exchanger is an evaporator in a heat pump system.

3. A heat exchange system according to claim 2 where at least part of the heat source heat exchanger is a condenser in a heat pump system.

4. A heat exchange system according to any one of claims 1 to 3 with the heat source heat exchanger configured such that the heat is distributed from the heat source medium through a fixed heat conduction medium and then into the material being dried.

5. A heat exchange system according to claim 4 where the fixed heat conduction medium is a thermally conducting plate with internal passages through which the heat source material flows.

6. A heat exchange system according to claims 4 or 5 where the material being dried is moved across the fixed heat conduction medium on a moving belt in thermal contact with the fixed heat conduction medium.

BEST AVAILABLE COPY

7. A heat exchange system according to claims 4 or 5 where the material being dried is spread over the fixed heat conduction medium and then removed after releasing some of its moisture to the drying gas.

8. A heat exchange system according to any one of claims 1 to 7 arranged to operate with the drying gas at a temperature between 25 and 90C.

9. A heat exchange system according to any one of claims 1 to 8 including means for rejecting heat from the drying apparatus to the external environment such as full time or periodic drying gas venting, pre-cooling the drying gas entering the evaporator, pre-cooling any make-up or purge drying gas entering or leaving the apparatus, sub-cooling the liquid heat pump refrigerant after it leaves the condenser and before it enters the evaporator, de-superheating the heat pump refrigerant leaving the compressor, or partially or wholly condensing the high-pressure refrigerant for purposes of control.

10. A heat sink exchange system according to any one of claims 1 to 9 arranged so that the drying gas passes over a substantially closed loop path repeatedly through the heat exchange system and past or through a drying zone containing a material to be dried.

11. A drying apparatus including:

a drying chamber where material is dried,

a drying gas to remove moisture from the material being dried, and

a heat source heat exchanger containing a heat source medium to heat the material being dried primarily by convection and/or conduction configured in such a way that the majority of heat transferred to the material being dried does not first pass through the drying gas stream so the drying gas stream primarily carries moisture away from the material being dried but does not carry the majority of heat into the material being dried, and

a heat sink heat exchanger containing a heat sink medium to cool and condense liquid out of a drying gas.

BEST AVAILABLE COPY

12. A heat pump for a drying apparatus including:

a condenser to heat the material being dried primarily by convention and/or conduction configured in such a way that the majority of heat transferred to the material being dried does not first pass through the drying gas stream so the drying gas stream primarily carries moisture away from the material being dried but does not carry the majority of majority of heat into the material being dried, and

an evaporator to cool and condense liquid out of a drying gas.

13. A heat exchange apparatus operable in a drying apparatus including:

a hot heat exchanger to heat the material being dried primarily by convection and/or conduction configured in such a way that the majority of heat transferred to the material being dried does not first pass through a drying gas stream so the drying gas stream primarily carries moisture away from the material being dried but does not carry the majority of heat into the material being dried, and

a cold heat exchanger to cool and condense liquid out of a drying gas.

14. A process for drying a material including:

causing a drying gas to remove moisture from the material being dried, and

heating the material being dried primarily by convection and/or conduction with a heat source heat exchanger containing a heat source medium where the majority of heat transferred to the material being dried does not first pass through the drying gas stream so the drying gas stream primarily carries moisture away from the material being dried but does not carry the majority of heat into the material being dried, and

cooling and condensing liquid out of a drying gas with a heat sink heat exchanger containing a heat sink medium and a heat sink heat transfer surface.

15. A drying process according to claim 14 wherein at least part of the heat sink heat exchanger is an evaporator in a heat pump system.

16. A drying process according to claim 15 wherein at least part of the heat source heat exchanger is a condenser in a heat pump system.

BEST AVAILABLE COPY

17. A drying process according to any one of claims 14 to 16 with the heat source heat exchange configured such that the heat is distributed from the heat source medium through a fixed heat conduction medium and then into the material being dried.

18. A drying process according to claim 17 where the fixed heat conduction medium is a thermally conducting plate with internal passages through which the heat source material flows.

19. A drying process according to claims 17 or 18 where the material being dried is moved across the fixed heat conduction medium on a moving belt in thermal contact with the fixed heat conduction medium.

20. A drying process according to claims 17 or 18 where the material being dried is spread over the fixed heat conduction medium and then removed after releasing some of its moisture to the drying gas.

21. A drying process according to any one of claims 14 to 20 including operation with the drying gas at a temperature between 25 and 90C.

22. A drying process according to any one of claims 14 to 21 including rejecting heat from the drying apparatus to the external environment such as full time or periodic drying gas venting, pre-cooling the drying gas entering the evaporator, pre-cooling any make-up or purge drying gas entering or leaving the apparatus, sub-cooling the liquid heat pump refrigerant after it leaves the condenser and before it enters the evaporator, de-superheating the heat pump refrigerant leaving the compressor, or partially or wholly condensing the high-pressure refrigerant for purposes of control.

23. A drying process according to any one of claims 14 to 22 arranging the drying gas to pass over a substantially closed loop path repeatedly through the heat exchange system and past or through a drying chamber for containing a material to be dried.

BEST AVAILABLE COPY

24. A heat pump apparatus operable in a drying apparatus with the heat pump evaporator in primary thermal contact with a drying gas medium after said drying gas medium has taken up moisture from the material being dried and the heat pump condenser in primary thermal contact with the material being dried and with both the drying gas medium and the heat pump refrigerant in nominally closed loop circulation paths.

25. A heat pump and drying apparatus including a drying chamber, a heat exchange apparatus and a drying gas stream, wherein the heat exchange apparatus includes a colder heat pump evaporator heat exchanger and a hotter heat pump condenser heat exchanger arranged such that during operation, the colder evaporator heat exchanger substantially exchanges heat with the moisture rich drying gas stream, and the hotter condenser heat exchanger substantially exchanges heat with the material being dried primarily by convection and/or conduction rather than the moisture lean drying gas stream.

26. A heat pump driven drying process with a drying gas stream, wherein the heat exchange is performed though a colder heat pump evaporator heat exchanger and a hotter heat pump condenser heat exchanger arranged such that during operation, the colder evaporator heat is exchanged substantially with the moisture rich drying gas stream, and the hotter condenser heat is exchanged substantially with the material being dried primarily by convection and/or conduction rather than the moisture lean drying gas stream.

BEST AVAILABLE COPY

REFERENCES CITED

	US 4,134,216	18 Nov. 1977	Stevens
	US 4,247,991	3 Feb. 1981	Mehta
5	US 4,466,202	21 Aug. 1984	Merten
	US 5,537,758	23 Jul. 1996	Guarise
	US 5,600,899	11 Feb. 1997	Stevens and Peeters
	US 5,862,609	26 Jan. 1999	Stevens and Peeters

Blundell C. J. *Energy conservation using improved heat pump dehumidifiers,* 10 Electricity Council Research Establishment, Capenhurst, UK. Published report presented at 2nd International CIB Symposium on Energy Conservation in the Built Environment, Copenhagen (1979).

Chen, G., Bannister, P., McHugh, J., Carrington, C. G., Sun, Z. F. *Design of Controlled Atmosphere Dehumidifier Fruit Driers.* IPENZ Transactions, (Institution of 15 Professional Engineers New Zealand) 27: 31–34 (2000)

BEST AVAILABLE COPY